Systems Analysis Department annual report 2002

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Systems Analysis Department

Annual Report 2002

Edited by Nijs Jan Duijm, Elin Jensen, Hans Larsen, and Stine Skipper

Risø National Laboratory

April 2002

Risø-R-1406 (EN)

This report describes the work of the Systems Analysis Department at Risø National Laboratory during 2002.

The department is undertaking research within Energy Systems Analysis, Energy, Environment and Development Planning – UNEP Centre, Safety, Reliability and Human Factors, and Technology Scenarios.

The report includes summary statistics and lists of publications, committees and staff members.

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and Stine Skipper

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Roskilde · Denmark

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Introduction

During 2002 the Department strengthened its international engagement, both through an increased volume of international research activities, and through a high number of international publications in journals, international reports and books.

The year 2002 has in many respects been a challenging year as the Finance Bill for 2002 included major cuts in funding for many Danish research programmes, such as the Energy Research Programme, which was reduced to about one-third of its former level. At the same time there have been discussions at all levels about the future role of sectoral research institutes, including Risø, and their links with industry and universities. Nevertheless, at the end of the year the Department had compensated for the more limited Danish funding with international involvement in new major projects, including several new EU-funded research projects and a major Clean Development Mechanisms (CDM) project funded by the Dutch Government.

Risø National Laboratory is devoting increased emphasis on research that can support sustainable development by ensuring economic development while at the same time meeting concerns for the environment. Research includes energy technologies and policies for post-Kyoto goals with regard to reducing the environmental impacts of energy consumption. In this connection, the Department was heavily involved in editing the Risø Energy Report 1 and in planning the Risø International Energy Conference to take place in May 2003.

Research activities were undertaken within the following research programmes:

- Technology Scenarios, *Per D. Andersen*
- Safety, Reliability and Human Factors, *Nijs J. Duijm*
- Energy, Environment and Development Planning, UNEP Centre, *John M. Christensen*
- Energy Systems Analysis, *Frits M. Andersen*

At the end of the year, it was agreed with the Steering Committee of The Global Network on Energy for Sustainable Development (GNESD) to locate a new secretariat as a separate unit in the Department. The secretariat will be fully staffed early in 2003.

The Department has a number of Scientific Advisory Panels to strengthen contact and interaction with Danish and international scientific communities and end users of results, e.g. industry, governmental authorities, and international organisations.

The Panels were asked to give strategic advice on the direction for future activities, as well as to assess the quality and relevance of ongoing and proposed activities. All the Panels met in the autumn and provided valuable input for the annual plan for 2003.

In 2002, 69 per cent of the department's activities were financed through national and international research contracts, contracts with national agencies and international organisations, as well as contracts with industrial companies – especially in the energy sector. The remaining 31 per cent of activities were financed by governmental appropriations.

The total gross / net turnover of the Department for 2002 amounted to approximately DKK 65.7 mill./DKK 53.1 (EUR 8.84 mill./ EUR 7.13)

At the end of the year, the total number of employees in the Department was 70. This included an academic staff of 65, namely, engineers, natural scientists, economists, and social and behavioural scientists, of whom nine were PhD students in co-operation with various universities in Denmark and abroad. There were four secretaries and one technician. During 2002 five staff members earned a PhD degree.

Hans Larsen, Head of Department

Technology Scenarios

The aim of the programme is to analyse commercial, societal and scientific possibilities and consequences in relation to selection, development and commercial application of new technologies. The programme focuses on technology foresight and other methodologies for prioritising science and technology in domains such as new energy technologies, plant biotechnology and emerging industrial technologies (i.e. nano technology).

Due to changes in the priorities of several government agencies, and the economic slow-down in 2002, only a few commercial consultancy tasks and projects have been carried out. In 2002 the programme successfully attracted new scientifically interesting projects. New projects were funded by the prestigious Carlsberg Foundation, the Danish Social Science Research Council, and the European Union's research programmes. As part of an EU consultancy task, a seminar on Regional Foresight was held at Risø in November 2002. Representatives from 10 Danish counties and regions participated in the seminar, that was attended by a total of 56 participants. In 2002 a feasibility study on "Technology Foresight in the Nordic Countries" was finalised. This project resulted in a large project proposal on "Hydrogen Energy Foresight in the Nordic Countries" with Risø as project leader and 15 Nordic partners from research, industry and other stakeholders. This proposal was approved for joint funding from the Nordic Innovation Fund and the Nordic Energy Research Program in 2003 – 2005.

In 2002 the PhD course in Management of Research and Innovation was carried out in collaboration with the Copenhagen Business School. The course has now been offered three times.

Per Dannemand Andersen
Head of Research Programme

Safety, Reliability and Human Factors

The aim of the research programme "Safety, Reliability and Human Factors" is to develop methods for analysing safety and reliability of complex technical systems, taking into account the technical, organisational, and human factors.

The year 2002 has been extremely busy. New EU-financed international co-operations were started, dealing with a variety of topics such as studying the use of ammonia as an alternative fuel for fuel cells and looking into new applications for enhanced visibility systems using infrared sensors. Another project is called "ARAMIS", and is being co-ordinated by INERIS, France. In this project Risø is responsible for developing an indicator to express the influence of the quality of safety management at a company on the risk for major accidents. This fits very well with increased activity in studying safety culture and safety management, where we also started a PhD project in co-operation with Roskilde University.

Large efforts have been made to ensure that Risø's activities at the Centre for Human-Machine Interaction (CHMI), which has received funding from the Danish National Research Foundation for the last five years, can continue by establishing formal co-operation with the University of Washington, Seattle, USA.

New statistical models for dealing with uncertainty have been under development for several years. This work accounts for about 25% of the programme's journal publications. For example, we are now arriving at practical methods to include expert judgement consistently in quantified assessments of risk and reliability, and this area looks promising for including human reliability in risk assessments.

Finally, about 15 man-months of work were actually performed in Hungary, in the framework of a Phare-twinning project on the implementation of the EU "Seveso" Directive on the control of major-accident hazards involving dangerous substances.

Nijs Jan Duijm
Head of Research Programme

Energy, Environment, and Development Planning, the UNEP Centre

The programme is the institutional framework for the UNEP Centre with the objective to be a leading international research and advisory centre on energy, environment and sustainable development, primarily in partnership with UNEP and developing-country institutions. Activities focus on development of analytical tools; analysis of global, regional and national energy, climate and sustainable development issues; and building analytical and planning capacity in developing countries.

Trends in 2002 have shown continued expansion of project-based activities in all areas, with a number of new energy activities funded by the UN Foundation through UNEP. The largest project ever for the Centre was on building capacity to implement Clean Development Mechanisms (CDM) in 12 developing countries. The project was funded by the Dutch government through UNEP, and initiation of a major international collaborative programme on Development and Climate Change was funded by the UNF and the governments of the Netherlands, France, Germany and Canada.

The World Summit on Sustainable Development, held in Johannesburg in August, involved a number of supporting activities and a number of Centre staff participated in the Summit as part of the UNEP delegation. At the Summit, UNEP launched a new major initiative – The Global Network on Energy for Sustainable Development (GNESD). The Centre had provided support to UNEP to prepare the initiative, and the first meeting of the international Steering Committee for the Network decided to locate the new Secretariat at Risø as a separate unit that will benefit from sharing location with the Centre.

John M. Christensen
Head of Research Programme

Energy Systems Analysis

The research programme is developing methods for analysing energy, environmental and economic issues, and interactions between these, as well as new energy technologies and their adaptation to complex energy systems.

The Centre on Environment, Economy, and Society was established jointly with the National Environmental Research Institute (NERI), and it comprises the joint activities within the Energy Systems Analysis Programme at Risø and the Department for Policy Analysis at NERI. The research areas covered by the Centre are environmental economics, integrated environmental information systems, estimates and forecasts of emissions, and sector analyses within land use, transport, and energy. Major activities in 2002 within the Energy Systems Analysis Programme were:

- Analyses and modelling of agents in interconnected markets for electricity, district heating and natural gas. Development of a CGE model of oligopolistic competition between suppliers in the three markets.
- Analyses of the dynamics and economics of improved technological development of renewable energy technologies. Estimation and interpretation of learning curves and analyses of instruments for supporting renewable technologies in a liberalised market.
- Analyses of the socio-economics of biogas plants.

Other activities were concerned with analyses of investments in renewable energy in Europe, assistance to the development of a national energy strategy in Lithuania, and forecasts of electricity consumption in Denmark. In addition two other major projects were started in 2002. The first involves analyses of security of supply in the electricity market, or market regulations that may ensure sufficient capacity in a Nordic electricity market. The second project addresses wind power integration in a liberalised European electricity market, including the development of an hour-by-hour simulation model for a Northern European electricity market with an integrated wind-power forecast model.

Frits M. Andersen
Head of Research Programme

TECHNOLOGY SCENARIOS

Regional foresight

Risø National Laboratory has assisted the European Commission in making a practical guide to regional foresight for Danish local and regional decision-makers.

The background for launching regional foresight activities is closely related to the Lisbon Strategy aiming at making the EU "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion" by 2010. To fulfil this ambitious goal a concerted action is needed not only by Member States, but also through bottom-up contributions from knowledge regions below and above national level.

The Danish practical guide was presented to practitioners and researchers involved in regional development and technology foresight at a public seminar on 26 November 2002 at Risø National Laboratory. More than 50 participants from technological information centres, regional development agencies, R&D institutions, educational institutions, and public agencies discussed how regional foresight may be a promising policy tool for prioritising regional development resources, for creating networks and strategies, and for building commitment and support for concrete regional actions. The practical guide is free of charge.

Birte Holst Jørgensen
Publication 2002: 38

The role of expectations in the emergence of nanotechnology

This REMAP PhD project takes the case of nanotechnology to examine the role of foresight in the constitution of a new technological domain. Qualitative studies conducted in 2001-2 in the nanotechnology arena evidenced the importance of expectations.

Expectations, in their mobility, productivity and influence, work to structure the orientation and activities of actors, and they are a key factor in gaining support and legitimacy for emerging technologies like nanotechnology. Such images of the future provide a rallying point for different actors to assert their positions, mark their territory, and claim their strength in setting the stage for a new technological field. The case of nanotechnology demonstrates how particular visions and expectations are sustained by some key players and rejected by others, depending on political, economic and social pressures. Expectations are embraced or rejected purposefully.

Managing the uncertainty of the future inevitably delves in the world of expectations. Expectations can be considered as a kind of anticipatory knowledge that has strategic importance in setting priorities and making decisions about science and technology. This research thus contributes to a better understanding of the dynamics necessary to consider in research policy and strategy formulation. Forthcoming research focuses on the temporality of expectations and the coordinating effects of expectations in relation to foresight.

Cynthia Selin

Experience curves for Danish wind power technology

Experience curves have attracted increasing interest in energy policy studies during the last decade. The concept of experience curves is based on the empirical observation that cost per unit of a standardised product falls as a firm or business sector gains experience in producing this product. This concept has been formulated in a more general way describing the relationship between an industrial sector (i.e. the wind turbine industry) and the cost of wind power. The term progress ration (PR) is derived from the slope of the experience curve and describes the percentage reduction in costs when cumulative production is doubled. If the cumulative installation of wind turbines is increased from 10,000 MW to 20,000 MW, the progress ratio might be approximately 85% – indicating that costs have decreased by 15%.

An EU project, EXTOOL, carried out by Lund University (study leader), ISET at Kassel University, and Risø National Laboratory was concluded in 2002. The objective of the EXTOOL project was to analyse the development of experience curve methodology for the analysis and assessment of energy policy programmes. As a part of the project, Risø National Laboratory analysed experience curves for Danish wind turbine technology from 1981 to 2000.

Cost reductions for wind power can be determined by at least two points of measurement 1) ex-works cost or prices of wind turbines (that is the cost of the equipment), 2) estimated cost of electricity (including improvements in efficiency and in operation and maintenance costs). The progress ratio for wind turbines manufactured in

Denmark based on ex-works turbine costs in Denmark has been determined at 91%. This progress ratio does not include effects from improvement in the efficiency of the turbines.

During the project we found that a more true and fair presentation will also take into account the improvements in the technical efficiency of wind turbines, and improvements in operation and maintenance costs. In the project we have been able to estimate the developments in the cost of electricity from wind turbines, and in this case the progress ratio was determined at 83% for the period 1981 to 2000. That is significantly better than the 91% mentioned above.

It might be too simplistic to calculate one experience curve for the first two decades of Danish wind power industry. Experience curves for Danish wind turbines can, for example, be divided in three parts reflecting the phases of development of the industry and the market.

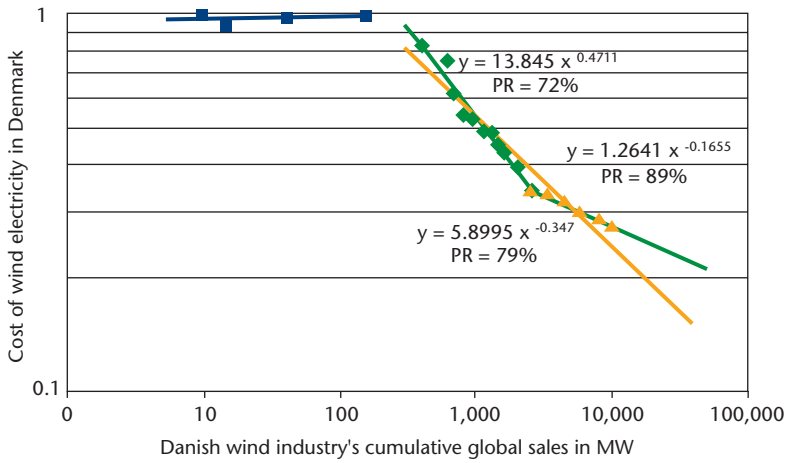
Part 1 covers the years 1981 to 1984. The conceptualisation and early development phase. From the mid-1970's until the early 1980's several wind turbine concepts were tested and produced by small firms entering the fledgling wind energy industry. In this phase the experience curve has a flat trajectory. See figure.

Part 2 covers 1985 to around 1995. The shake-out phase. After 1984 a number of new firms entered the wind turbine industry due to the Californian wind turbine export boom in 1983 and 1984. A lot of money was earned during this boom, and a number of newcomers were attracted due to this business opportunity. In early 1990's the Danish market was at a relatively low level, which probably led to increased competition in Denmark. The progress ratio in this period was as high as 72%.

Part 3 covers from around 1995 to 2000. The rapid growth phase. From 1995 the world market for wind turbines has experienced a rapid growth with average annual growth rates over 30%. Here, the experience curve has a progress ratio of 89%. For the period 1985 to 2000 the progress ratio was 79% and it is reasonable to expect that a progress ratio of between 79% and 89% will continue for the next decade. Extrapolation beyond 2010 cannot be made without large uncertainties, and such extrapolations must be qualified by other foresight methodologies such as scenario building.

The figure shows an experience curve for Danish Wind turbine technology 1981 – 2000. The cost axis is based on the estimated cost of wind electricity in Denmark (roughness class 1, interest rate 6% and a cost model for cost of operation and maintenance). The market volume axis is based on Danish wind turbine manufacturers' cumulative annual sales world-wide. The progress ratio for the period 1985 to 2000 equals 79%. The progress ratio for the period 1994 to 2000 equals 89%.

Per Dannemand Andersen,
Helge V. Larsen, Poul Erik Morthorst



Venture capital – Managing innovation in a mode of fluctuation and chaos

During the last decade, we have seen how companies have initiated substantial processes of outsourcing, mergers and acquisitions. A result of these processes is that companies are more frequently engaged in a plurality of collaborations, making the boundaries of the firm blurred. The changes also apply to innovation, where the mode of managing growth and change has moved from the boundaries of the firm towards managing trans-disciplinary, inter-firm innovation. In other words, changes where innovation arises not only within existing boundaries of the firm, but also across a wide variety of levels and boundaries, and where the critical task of companies is to facilitate this kind of innovation.

As a part of REMAP (a research collaboration between Copenhagen Business School, Risø National Laboratory, the Danish Institute for Studies in Research and Research Policy, and six industrial partners, see www.remap.dk), this PhD study is devoted to exploring and creating an understanding for the implications of managing the flux and chaos in this new mode of innovation. The project has its primary empirical inspiration and point of departure in the practice of corporate venture capital (CVC). The project has followed the corporate venture capital unit of TDC Innovation A/S and its various collaborating partners for nearly two years.

Corporate venture capital

Building upon comprehensive field observation and participation, CVC is a strategy that assumes flexible interactions across multiple contexts and dimensions. There are no canonical definitions of CVC, but it is often described as an inter-firm collaboration in which a company with a dedicated pool of capital acquires shares or convertible bonds in the earlier stages of privately-held new initiatives with the aim of capitalising on the continuous development of new methods, products, markets, businesses and/or business models. The CVC activity differs from the more traditional modes of innovation, like scientific research and technology development, in that it emphasises market orientation, where new ventures are both selected and nurtured outside the existing boundaries of firms. CVC investments are inter-firm collaborations, meaning that there are often many investors involved and that such investors and their ventures interact with a wide variety of professionals outside the boundaries of the firm. Venture capitalists engage across communities of practice, where all actors are dependent on each other, not only for buying and selling new ventures, but also for developing important networks, knowledge, expertise and reputations for the new ventures.

Managing fluctuation and chaos

A central empirical observation in this project is that there is a difference between what venture capitalists say, and what they actually do. Venture capitalists are usually highly reflexive about what they are saying, how they describe their practice, and how they legitimise their decisions and results. However, the actual meaning the venture capitialists assign to their practice remains unspoken; as taken-for-granted and tacitly accepted meanings of practice. The difference between what is said and what is meant reveals a crucial management mechanism.

The stories venture capitalists tell serve the purpose of relating to or creating expectations of something new. Stories are continually modified on the basis of the credibility they receive. In this legitimisation process, they may be dropped altogether, replaced, or become more coherent. This is a delusional process, where the story is constantly exposed to a public who render their opinion (verbally or non-verbally) only to encounter the story again and again until the storyteller is satisfied with their reaction.

Storytelling creates an identity and is a way of remembering and keeping track of the past – thus relating to the future through prior experience. It is a way of categorising in order to make sense of the world, people and alliances. The economisation of categories establishes a common ground, or a standardisation of stories, which in turn signals values and thus establishes boundaries that distinguish one storyteller from another. The stories constitute battles of values and may be 'violent' as they involve honour, reputation and identity. Yet as time goes by, a historical pattern usually emerges, even though some individuals or even groups may have been dissolved, separated, or become isolated. The pattern is not necessarily a signal of success as it only represents a contemporary "status" of the new venture. Nevertheless, it is a crucial stabilisation since capitalisation assumes stability and transparency. Even if it is not well received by the environment, the venture may still represent a basis upon which an illusion may be created of harmony and lack of risk; an illusion of a good investment.

This PhD project is an elaboration of the dual and chaotic nature of corporate venture capital. The contribution is how management, through interaction with a variety of actors, competes and collaborates at different dimensions and levels by using a variety of symbols, rituals and ceremonies, all of which institutionalise the myth as either success or failure.

Jon Olav Pedersen

SAFETY, RELIABILITY AND HUMAN FACTORS

Reporting and learning from errors and other adverse events in hospitals

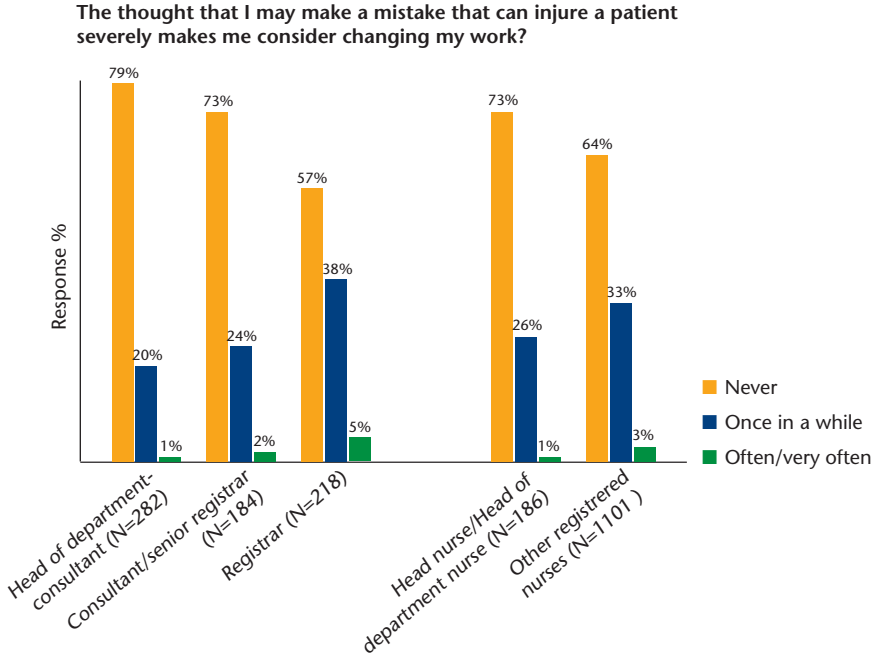
A national project about requirements for a reporting system of adverse events in hospitals was carried out in 2001-02 for the Danish Ministry of the Interior and Health. The goal of the project was to develop recommendations for a system of reporting adverse events in hospitals and for promoting organisational learning from such events. Risø's role in the project was to contribute knowledge about incident-reporting schemes in aviation and other non-medical domains and to transfer experience with conducting questionnaire-based surveys of safety culture.

The project based its recommendations on a review of international experience with reporting systems, interviews with doctors and nurses, and a comprehensive survey of the views of doctors and nurses on reporting adverse events.

For the survey part, a questionnaire was developed comprising about 100 single question items about how respondents think they themselves would react to events in which a patient is injured by medical mistakes, and how they would want such events to be dealt with and reported. At the same time, the questionnaire sought to elicit the views of healthcare staff about the barriers they perceive against bringing up incidents with colleagues or leaders, or informing the patient involved. The survey, which comprised more than 2000 doctors and nurses in four counties in Denmark, is the most comprehensive – in terms of respondents and issues covered – that has been made to uncover the views of healthcare staff regarding medical mistakes.

The recommendations of the project group include the following:

- That a system of unconditional, confidential reporting is introduced ensuring that the identity of the reporting healthcare staff member is not made known outside the ward or department.
- That a distinction is made in principle and in practice between disciplinary and learning functions of reporting.
- That the name of the department is not made known in statistics of reported adverse events.
- That healthcare staff are obliged to report adverse events of given generically defined types.
- That discretionary reporting should be encouraged over and above mandatory reporting of the core set of generically defined events.
- That reporting should be made locally, "near" the adverse event, thus enabling dialogue and feedback



Almost one-third of doctors and a slightly smaller proportion of registered nurses occasionally think about leaving their job due to the risk of making an error or causing harm to a patient. The results also show that young and junior doctors and nurses in particular think about leaving their job.

with the reporting staff member. Data should be transmitted in an anonymous format into a national database of adverse events.

The Ministry of the Interior and Health has adopted the recommendations in its background materials for a new law on patient safety, including incident reporting. The project was carried out in collaboration with DSI (the Danish Institute for Health Services Research) and the Danish Institute of Medical Simulation, Herlev Hospital.

Henning Boje Andersen, Marlene Dyrløv Madsen
Publications 2002: 66, 92, 105, 120

Assistance to the implementation of EU legislation in Hungary

As part of Hungary's preparations for accession into the European Union, a number of so-called Twinning Projects are being carried out in order to enable the Hungarian authorities to enforce EU legislation. The Twinning projects are being partly financed by the EU's PHARE programme.

One such project aims at enabling the Hungarian National Disaster Prevention Directorate and its regional offices to enforce Hungarian legislation related to the so-called Seveso II Directive concerning the control of risks from chemical industry. A consortium, led by SPM, is carrying out the Twinning Project, which started in February 2002 and will end by April 2003.

The twinning arrangement includes a Pre-Accession Adviser (PAA), who is resident in Hungary and assigned to the National Directorate General for Disaster Manage-

There are several large industrial sites in Hungary built using out-of-date Russian technology. These sites are now being split into smaller privately owned units. This represents a challenge to good safety management, for instance concerning questions such as: "Who feels responsible for the pipeline that links the installations?"

Key elements of the PHARE Twinning project on the implementation of the EU "Seveso-II" Directive in Hungary are:

- Training of Hungarian experts for their new tasks, i.e.:
  - evaluation and assessment of safety reports and -analyses, safety management systems and internal emergency plans
  - preparation of external emergency plans and leaflets for information to the public
  - drafting of authorisations and decision on Land Use Planning (LUP)
  - handling of actual emergency situations

This goal was accomplished through three training seminars, each lasting three weeks. In total around 130 persons were trained

- A manual for the authorisation of companies. The manual will be based on findings from a series of case studies addressing process types of particular importance in Hungary. It will serve as a guideline and a "standard procedure" for authority staff.
- A study tour for selected Hungarian staff to Denmark where they had a first hand impression of the management of the Seveso II legislation in an EU Member State.

ment for a period of 12 months. The PAA is running the project with the help of so-called short-term experts (STEs) from Risø and partners. A project manager at Risø is responsible for overall achievement of the scheduled results.

Apart from Risø staff, short-term experts come from COWI consulting engineers, the Danish Emergency Management Agency's Staff College, Copenhagen County, and RIVM in the Netherlands.

In addition to the Hungarian project, SPM staff are currently involved as short-term experts in similar projects in Poland and Bulgaria.

Kurt Lauridsen

Analysing Team Situation Awareness

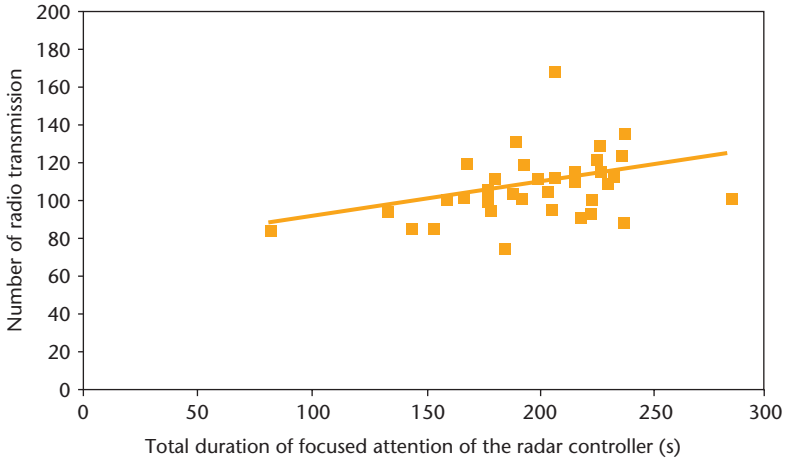
The notion of Situation Awareness has been used extensively since about the early 1980's in the literature on human factors. Situation Awareness (SA) was originally introduced in order to explain why and how otherwise skilled people loose control of the system they are operating. The types of breakdown of system control, which the SA concept was meant to capture, involve:

- Human operators loosing track of or missing task cues.
- Human operators failing to integrate available cues into a coherent or valid mental model of the system to be controlled

A loss of sufficient SA may lead to human errors, possibly resulting in accidents. The relationship between situational awareness and aviation safety is generally accepted, but it is not completely understood. In recent years, research has been directed toward understanding individual SA and, accordingly, training has been aimed at maintaining the individual operator's SA. It is becoming increasingly clear, however, that Team Situation Awareness (TSA) is also an important concept. The VINTHEC II (Visual Interaction and Human Effectiveness in the Cockpit – Part II) project explores the relationship between aviation safety and crew interaction in terms of Team Situation Awareness; examining how the aviation training community and cockpit designers might monitor crew behaviour. One measure of Team Situation Awareness developed at Risø deserves mention here:

Distributed versus focused visual attention: Distributed visual attention implies looking at several elements of information for a short period of time. Focused visual attention implies looking at a few, selected pieces of information for longer periods of time. The hypothesis is that simultaneous, focused visual behaviour for all team members could indicate a lower degree of TSA.

The measure was explored in a PhD study of Air Traffic Controller (ATC) trainees. Data collection took place at the School of Air Traffic close to Copenhagen Airport, Kastrup, in a full-scale ATC simulator. 35 ATC trainees took part in the experiment.



There is a statistically significant correlation between the total duration the radar controller uses a focused visual search/ monitoring strategy, and performance in terms of the number of radio transmissions from the radar controller during the complete session.

In ATC, efficient use of radio communication is an indicator of good performance of the oper experiment, the number of radio transmissions was the primary measure for system performance, a higher number of transmissions indicating worse performance.

One result from this study is that the use of a focused monitor and search strategy (having focus on a specific area with information for a long time) may be less effective. When the radar controller focuses his/her attention on a specific area of interest then the data show that the number of radio transmissions seems to increase.

Hans H. K. Andersen; Gunnar Hauland
Publications 2002: 79, 116

A new type of quick-shutting safety valve

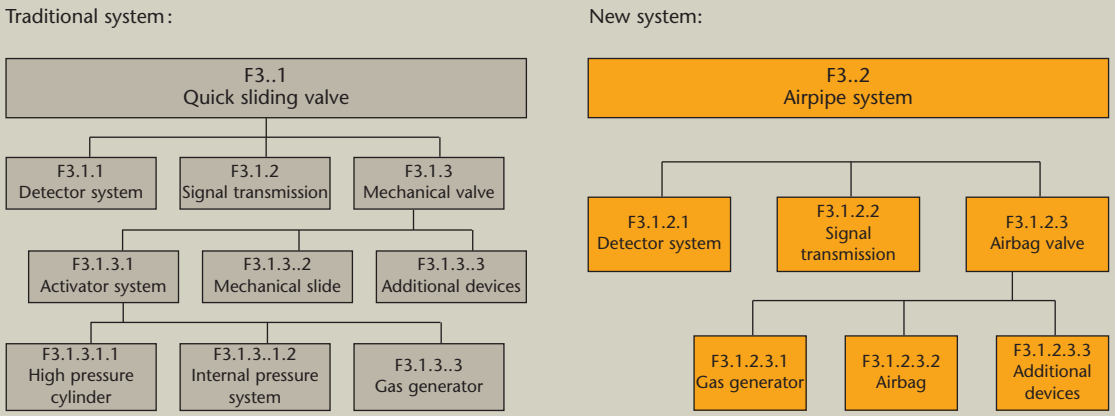
In modern factories safety valves are important parts in installations and their connecting pipelines to prevent explosion and fire accidents, to mitigate hazards, to improve safety, and to protect the environment. This is particularly important for power generation, and the chemical, petrochemical, mining and agro-food industries. Accidents are often connected with the handling of flammable/explosive solid powders, liquids and gases that, for example, are transported in pipelines or ducts with diameters of up to two meters. In order to protect against detonations inside a pipe, the safety valve needs to close the pipe within milliseconds. Nowadays, no quick-shutting device exists for the largest diameters, as the existent quick-sliding valves are limited to pipe diameters below 0.6 m.

On this background, the project AIRPIPE – airbag for the closing of pipelines on explosions and leakages started in February 2002. The basic idea is to apply the well-known airbag technology from the car industry to close pipelines within milliseconds. The project is being funded under the European Competitive and Sustainable Growth programme. Ten partners from different European countries co-ordinated by the Fraunhofer Institut for Chemical Technology, (D) are conducting this 3-year project.

The project is designing, developing and testing prototypes of the new valve and its components. Thus, new airbag materials and suitable gas generators, including up-scaling the production of the energetic materials needed, are being investigated, and pilot closure systems will be constructed and tested using the different application scenarios established. The technical aspects are being monitored and supported using safety assessment and other means in order to improve the societal acceptance, competitiveness and sustainable nature of the new closure device.

Risø is task leader for the latter activity and will perform risk assessment, life cycle analysis combined with multi-decision-support strategies and cost-benefit investigations to find the best solution for the different scenarios. This will give feedback to the technical aspects, for example to improve the safety and reliability of the new valve prototype. This approach is believed to support the development of inherently safer systems, as during the design and test phase of a new technical system, any

Safety valves. Functional decomposition of a traditional Quick-Sliding Valve and the new AIRPIPE system.



proposed (safety) improvements are more easily and cheaply implemented.

During the first year of the project the consortium has selected two types of test applications; a high-pressure application for a typical gas pipeline used for natural gas transport, and a lower pressure application typical for pipe connections within powder drying equipment, for example. Furthermore, encouraging shock-tube tests on different materials have been made to see if they can withstand the high pressures. Risø's main task was to make a preliminary estimation on the benefits of the new type of safety valve compared to the existing valves. In order to do this, suitable models have been adopted, such as functional modelling. A framework for reliability and cost-benefit analysis has been set up on the basis of which the major task of data collection has already been started. In this way it has been possible to give a preliminary estimate on the benefits of the new valve.

Frank Markert

Centre for Human-Machine Interaction

The Centre addresses a current world-wide problem: information systems and technology are being developed at an accelerated pace, and their use is spreading rapidly, but our understanding of how humans interact with information is very limited.

As a result, many systems and technologies do not serve their users effectively. The Centre is addressing this problem in several ways: research projects are being funded by the EU (Collate) and in the USA by the NSF (CIR), where the Centre's responsibility is firstly to bring about methods for work analysis that will draw the designers' attention to the users' problem-solving activity and, secondly, to bring about methods for experimental design and evaluation of information systems.

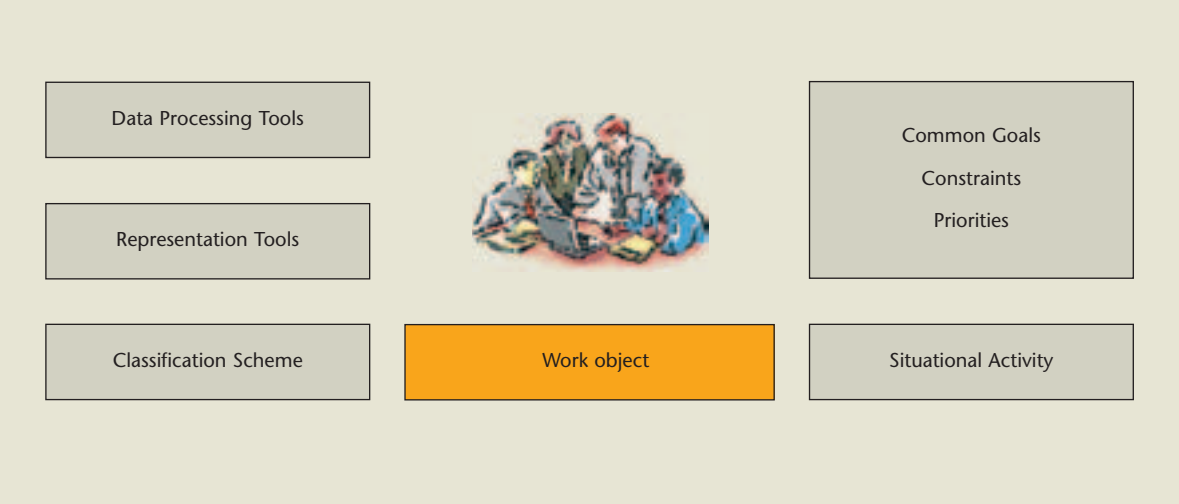
Development of courses for teaching university students and supervision of PhD students also serve to address theoretical and methodological approaches related to the design of systems that serve users effectively.

Teaching Curriculum

During 2002, the CHMI has been extensively involved in a collaboration with the Information School at the University of Washington, Seattle. A new activity in this collaboration has been the development of a teaching curriculum in Cognitive Systems Engineering methods, developed at Risø. This is the only approach that integrates users' problem solving with organisational contexts, and offers a mechanism to transfer results from work analysis directly to design requirements.

The objectives of the curriculum are for students to understand the basic concepts and models of Cognitive Systems Engineering and know-how in order to:

- conduct field studies in a work domain and perform data analysis
- analyse data according to the Means-Ends model of a work domain
- identify the way work is organised and the way tasks



The figure shows the common workspace of a collaborative work task.

and decisions are distributed among actors in a work domain
- identify actors' information needs, the strategies that actors employ in their tasks, and the resources, values, and preferences of individual actors
- develop requirements for an information system to satisfy the actors' needs
- conduct an evaluation of an existing, or proposed, information system guided by the work analysis

Providing courses that introduce students to this method is intended to mediate our Cognitive Systems Engineering research methods to international teaching environments for the benefit of society. For the University of Washington such courses will strengthen the teaching goal to educate students to carry out work in the real world on the basis of solid research and with an impact. Initial workshops introducing the course to Masters degree students in the Information School were conducted in the autumn of 2002 and the full implementation of this course begins January 2003.

Classification schemes

The main goal of the PhD project named "Classification Schemes for Collection Mediation: Work-Centred design and Cognitive Work Analysis" is to gain insight into the collaborative construction and integration of knowledge into work-based classification schemes.

New types of information technology such as web-based collaboration need to have classification schemes to support collaborating users in getting an overview of the contents and use potentials of a collection.

A classification scheme is a conceptual tool that makes visible a shared semantic structure of a work domain. The thesis applied cognitive work analysis to model collaboration in the domains and to building models for work-centred design of classification schemes. Four empirical studies were conducted using focus groups, interviews and participant observations of the work situations in which people engage in joint negotiations about how to integrate knowledge.

A result of this work is models of the common workspace showing the context of a collaborative task: symbolic resources, work object, and actors and their goals/constraints and priorities (see figure). Together, these elements constitute the possibilities and constraints for action in the common workspace.

The thesis concludes that the use potentials of collections, i.e. the possible use of information in collections by different actors for specific tasks, shape the structures and contents of classification schemes. Therefore, the design of work-based classification schemes that make visible the use potentials of the information in a collection should be based on a Cognitive Work Analysis of the actors' information needs in collaborative work tasks and a corresponding analysis of the use potentials of a shared collection.

Annelise Mark Pejtersen, Hanne Albrechtsen

Publications 2002: 31, 32, 33, 83, 104, 107, 117, 118, 119

ENERGY, ENVIRONMENT AND DEVELOPMENT PLANNING, THE UNEP CENTRE

A number of important events have taken place in 2002 for the Energy, Environment and Development programme as the institutional framework for the UNEP Collaborating Centre on Energy and Environment (UCCEE) and the new secretariat for Global Network on Energy for Sustainable Development (GNESD).

The Global Network on Energy for Sustainable Development (GNESD) was launched at the World Summit in Johannesburg in August 2002. The Centre had supported the UNEP Energy Programme in preparing the new initiative, and on an interim basis, the Secretariat for the GNESD is located at Risø as an independent unit next to the Centre.

The GNESD aims to promote sustainable development and poverty alleviation through identifying policies and solutions, which expand access to environmentally sound energy services. This will be done by linking established Centres of excellence and regional networks and thereby expanding their expertise and impact through joint activities on information exchange, analytical studies, policy support and capacity building. The Network offers new interesting areas of collaboration and the Centre will become a very active network partner.

For the UNEP Centre the overall trend has been a continued expansion of activities and staff combined with a consolidation of the Centre's leading international position in its core substantive areas energy, climate and sustainable development. A new four year core contract was approved early in the year by the three founding organisations (UNEP; Danida and Risø) providing a sound basis for the centre activities.

Activities at the UNEP Centre are grouped into three research areas: Energy, Climate Change and Sustainable Development. In early 2003 a matrix management structure will be implemented to enhance research area development and coordination. As the matrix structure indicates, activities often contribute to all areas, and in general most activities integrate different aspects of energy and climate change in a sustainable-development context. The presentations below are structured to show the major activities in each area.

John M. Christensen

Energy Research Area

Activities in the energy research area focus on energy policy support, institutional reforms and approaches to overcoming barriers to renewable energy (RE), as well as energy efficiency (EE) projects, in particular projects examining financial issues. Short summaries of the main projects are presented in the following sections.

Photovoltaic Solar Home System, Financing Project

One of the main barriers to the development of markets for clean energy is access to finance. As part of continuing efforts to address this barrier and promote innovative options to finance clean energy services, a new project was approved in July 2002. Financing PV Solar Home Systems is a three-and-a-half-year project to accelerate the market for credit finance of photovoltaic solar home systems (SHS) in the southern Indian state of Karnataka. Funded by the United Nations Foundation (UNF) and the Shell Foundation, the project is a partnership between UNEP, the UNEP Centre, and two of India's major banking groups – the Syndicate Bank and the Canara Bank.

During the project planning phase in 2002, barriers were identified: high initial cost, a lack of financing due to high-risk perception by the financial institutions, and high financing costs even if finances were to be made available. The overall aim of the project planning was therefore to develop a credit facility to help

Two Indian women in front of their house with a PV Solar on the roof. *Photo: NREL*

Indian banking partners develop lending portfolios specifically targeted at financing solar home systems, hitherto poorly served by conventional financial institutions.

The UNEP Centre consulted the banks about the structure of the credit facilities including financing terms and conditions that the banks will offer to SHS customers. The credit facility will use UNF resources to "buy-down" the cost of financing SHS at retail level – in effect, providing a subsidy that lowers the effective interest rate on a loan taken by a customer to purchase a system. Theoretically, a fund of US$1 million could provide loan interest subsidies to purchase almost 20,000 solar home systems.

This relatively new approach differs from the traditional programmes of capital cost subsidies to purchase systems, and hence it is expected to be more effective at avoiding price distortions, while sustainably developing the market. One of the main differences in this approach is an inherent design to make concessional finance unnecessary once the barriers faced by mainstream financial institutions – such as perceptions the technology will not work as designed – have been addressed, and solar customers have proven their credit-worthiness.

One of the unique features of the project is technical support by the UNEP Centre to the partner banks in view of their unfamiliarity with the technology, which has been an important barrier to financing. UNEP Centre has drawn up the product specifications and carried out vendor qualification process to ensure supply of quality product and an efficient after sales service, both crucial to acceptance of the SHS by consumer, and hence for success of the project. UNEP Centre is also providing a checklist for product appraisal, which will help bank managers in the field to streamline the loan approval process and reduce their transaction costs. Credit facility structure has been finalised with the banks and the facilities will start operations during second quarter of 2003.

The Project will also develop a network with a number of institutions, including the Indian Government's Ministry of Non-conventional Energy Sources (MNES) – an apex Indian government body promoting renewable energy, which is launching a similar programme to promote SHS in a number of Indian states.

The UNEP Centre will also liaise with other relevant agencies to develop policy guidelines that encourage banks to offer loans for the purchase of an SHS and also to provide a platform to communicate financial ideas and support to banks and other financial institutions. UNEP support includes sponsoring joint workshops with these agencies to share knowledge and promote SHS in the financial community.

Financing Mechanisms for Energy-Efficiency Projects in Brazil, China and India

UNEP, the UNEP Centre and the World Bank will implement a project to achieve a major increase in energy-efficiency investments by the domestic financial sectors in Brazil, China and India. With financial support from the United Nations Foundation (UNF), the project is developing the capability for new and existing financial institutions to package energy efficiency investment projects by removing market barriers in each country. Project duration is 2002-2005.

Through studies and consultations in 2002, barriers to energy-efficiency financing by banks were identified, and they provided clear evidence that barriers to increasing the development of energy efficiency are similar among countries, even though the underlying causes may be quite different. Action plans have been made for each country to overcome these barriers.

Project activities:

- Develop commercial banking opportunities for energy-efficiency project
- Support energy service companies (ESCOs)
- Create guarantee funds for energy efficiency
- Develop equity funding for ESCOs/energy efficiency projects

The UNEP Centre is working jointly with the World Bank, and teams from each country, and will be responsible for disseminating information, organising four cross-exchange workshops and conducting a final project workshop.

The Rural Energy Enterprise Development Project

The Rural Energy Enterprise Development (REED) programme was initiated in five African countries under the project AREED, and has now also been implemented in Brazil (B-REED). The REED programme generally seeks to develop small energy enterprises using sustainable technologies to meet the energy needs of populations under-served by conventional means in urban and rural areas. In addition, the programme focuses on building the necessary capacity for continued enterprise development services in local institutions and at policy level to create and enable the environment.

Regarding policy issues B-REED intends to help local, state and federal governments to integrate a role for small sustainable energy enterprises in the restructuring process of the Brazilian power sector. This process is aimed at increasing competition and private-sector participation. To this end, a new set of laws and regulations is being

gradually rolled out. The initial assessment carried out by the UNEP Centre identified two outstanding policy issues that might affect the further development of small rural sustainable energy enterprises in Brazil: subsidies not reaching off-grid consumers and the concession scheme for electricity supply. A new law (10.438), adopted in April 2002, deals precisely with these issues. There are many open issues in the new law that will have to be defined by implementing regulation.

Following consultations by the UNEP Centre with local parties and stakeholders, it was decided to develop a first policy support activity on how to integrate a role for small rural sustainable energy enterprises into the implementing regulation of Law 10.438. The support includes stakeholder consultations, a policy workshop, and support to energy entrepreneurs on policy issues. The policy support started in October 2002 and should be completed by June 2003. The early activities were delayed due to the presidential elections in Brazil.

Jyoti Painuly & Juan Zak

Publications 2002: 45, 53, 54, 58, 60, 61

Climate Change Research Area

The UNEP Centre has been active in many areas of work related to climate change over the past decade, and while the focus is predominantly on issues related to mitigation, a new sub-programme is being established to deal with approaches to analysing adaptation strategies and activities. This development reflects the increasing political focus on making adaptation more operational, and the fact that existing internal expertise can form the basis for a logical expansion of the portfolio of activities.

A first project activity on tools and methods for assessing adaptation projects is under implementation with partners in South Africa and Gambia funded by the GEF, the World Bank and the US-EPA.

The support to countries in preparing their national communications is continuing in collaboration with UNDP, and funded by the EU. Focus is on direct support to weak-country teams, broader training workshops and reviews of draft communications.

The UNEP Centre has also continued its support to the African group of UN Framework Convention on Climate Change (UNFCCC) negotiators and convened a workshop before the Conference of Parties (COP 8) to facilitate a discussion and position development for a core group of African negotiators. During the COP 8 the UNEP Centre also actively supported the group on an ad-hoc basis.

Finally, over the years the UNEP Centre has had a strong involvement in the Intergovernmental Panel on Climate Change (IPCC), which was further enhanced in 2002 with the election of John Christensen to the IPCC Bureau as a vice co-chair of Working Group III.

Capacity Development for the Clean Development Mechanism Project

The main objective of this Dutch-funded project is to generate a broad understanding of the opportunities offered by the Clean Development Mechanism in the developing countries, and develop necessary institutional capability and human resources to participate fully as equal partners with developed countries in the formulation and implementation of the Clean Development Mechanism (CDM).

The project will help establish greenhouse-gas emissions-reduction projects that are consistent with national sustainable development goals, particularly projects in the energy sector. It will develop national capabilities so that people in the countries will be capable of analysing the technical and financial merits of projects, and negotiating possible finance agreements with Annex 1 countries or investors. Unlike other CDM capacity-building projects, this project is "investment-neutral" and unconnected to the actual purchase of carbon credits from possible CDM projects.

Africa	Asia	Middle East & North Africa	Latin America
Cote D'Ivoire	Cambodia	Egypt	Bolivia
Mozambique	Philippines	Jordan	Ecuador
Uganda	Vietnam	Morocco	Guatemala

The programme was launched in early 2002 and involves 12 small- and medium-sized countries from four regions: sub-Saharan Africa, Asia, the Middle-East and North Africa, and Latin America.

After the initial country selection, the program is implemented in two phases. Phase 1 was implemented in 2002 with the main objective of establishing a national focal point, sensitise the government support, and develop a national work plan for Phase II based on studies of the existing capacity, country-specific needs, and the

legal and institutional framework in each participating country.

In Phase II, project implementation will be based on the national work plan to meet the overall goals of establishing a national CDM authority, identifying potential CDM projects, and creating a pipeline of real CDM projects in a country-specific and cost-effective manner.

The Centre is managing the overall project and supporting implementation at national level. A group of regional centres have been contracted to help in the implementation of the project in various ways such as preparing background papers, collecting data & information, convening workshops, and providing technical assistance to national teams.

As one of the first outputs, a popular introduction to the CDM has been prepared and is being used in the national meetings. Later it will be used in the national and regional workshops. This document is now being translated into all relevant languages. Since this project is one of the largest capacity-development programmes for CDM, an Advisory Body has been established with the main objective of ensuring coordination of activities and efficient information exchange on new initiatives and underlying analytical work. Members are from the main bi- and multilateral institutions involved in capacity building for CDM, such as the Netherlands Ministry of Foreign Affairs, UNIDO, the World Bank, UNDP, UNFCCC Secretariat and ADB.

The CDM programme also includes the development of methodologies and tools that can support countries in developing and managing CDM project supply. The focal areas of the methodological work include:

- CDM project guidance material, that goes through all the CDM project cycle steps.
- Approaches for national baseline scenario development.
- Assessment of sustainable development impacts of CDM projects.
- Legal, institutional, and financial framework for CDM project development.

The methodological work includes a number of popular guidance documents, technical background papers, and training material. The idea is to combine the available "best elements" of internationally available material and add elaborated material on specific focal areas. Special emphasis is on providing background material that contributes to enhancing national capacities for participating in CDM, so that the projects are in accordance with national development priorities and support sustainable development. Important sub-issues that can contribute to this capacity building include outlining a framework for national decision-making that can govern CDM supply in a way that facilitates participation of a broad range of national stakeholders and allows an integrated evaluation of CDM project finance and how projects can support major development priorities.

Myung Lee & Kirsten Halsnæs

Publications 2002: 6, 7, 13, 29 50, 52, 55

Sustainable Development Research Area

While the Energy and Climate Change research activities at the UNEP Centre have always been framed in a sustainable-development context, it is only within the last couple of years that the Centre has developed a programme of activities with a direct and broad development focus.

Activities have focused on conceptualising and operationalising sustainability criteria in relation to programmes and projects, predominantly in energy and climate change, but also reaching into broader poverty eradication activities.

Development and Climate Change Project

The project is being implemented in a global partnership with centres of excellence in the Netherlands, the UK, France, Canada, the USA, Germany, Brazil, South Africa, Senegal, Bangladesh, India and China. The aim is to identify development paths that also meet climate policy

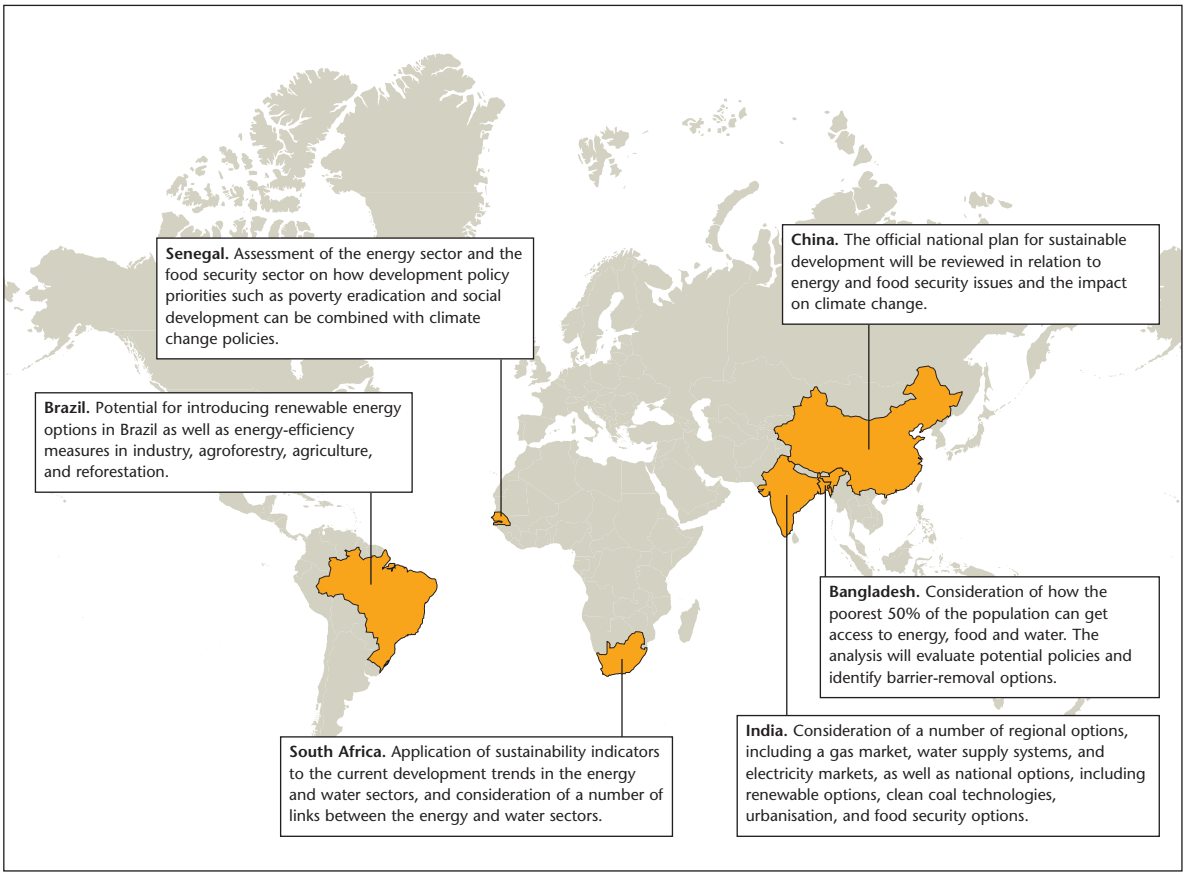
objectives, including adaptation as well as mitigation policies. On the one hand, the project recognises that in many developing countries a number of immediate issues such as poverty, food security, health, natural resource management, energy access, and urban transport are considered to be more important than climate change. On the other hand, there are many good examples of development initiatives that have positive impacts on climate change in terms of reduced vulnerability and lower GHG emissions.

The project takes its starting point in identifying links between development and climate change policies. An assessment of the development and climate change literature has identified close links between core development factors like economic growth, technological change, resource utilisation, human resources and equity, and the capacity to adapt to climate change or to mitigate it. Many development projects will have positive side effects on climate change in the form of reduced GHG emissions, improved local environment, and institutional and human capacity building.

One of the tools that will be used to assess links between development and climate change is to apply indicators of sustainable development to the evaluation of specific policies. Sustainable development indicators are designed to represent the economic, environmental, social and human aspects of policies in an integrated framework.

Hundreds of different theoretical definitions of sustainable development have been suggested in the literature, and it is not possible to encompass all these dimensions and issues in a practical policy study. The Development and Climate Project takes a very pragmatic approach to the definition of sustainable development indicators, and recommends that the countries select a limited number of areas that they would like to reflect in their specific policy studies.

The project partners will simultaneously undertake studies and conduct policy dialogues about how long-term integrated development and climate change goals can be achieved through promoting a long-term transition process in the energy sector and the food/water sectors. Case studies for Brazil, South Africa, Senegal, Bangladesh, India, and China will provide specific examples of policies and projects that can be used in this transition.



The figure shows an overview of country studies.

Examples of sustainable development indicators of relevance to climate policies

		Sustainable Development Indicator
Economic	Growth	Gross Domestic Product
		Foreign direct investments and direct investments
		Net costs, financial flows
	Sectoral development	Activity in energy sector, industry, agriculture etc.
	Technological innovation	Technology access
		Market creation
		Learning
Environment	Climate change	GHG emissions,
	Air pollution	Local air pollution, particulates
	Other emissions	Rivers, lakes, irrigation, drinking water
	Exhaustible resources	Fossil fuels
	Biodiversity	Specific species
Human	Education	Literacy rates, primary and secondary education
	Health	Life expectancy, Infant mortality, Major diseases,Nutrition
Social	Information sharing	Institutions, markets, formal and informal networks
	Equity	Distribution of costs and benefits, income distribution, local participation
	Poverty alleviation	Income or capabilities created for poor people

The table shows examples of sustainable development indicators including more conventional measures of economic growth, investments and sectoral activity, as well as indicators of technology use and penetration. Another important sustainability dimension is the impacts on the global and local environment including air and water pollution as well as biodiversity and use of exhaustible resources. Finally sustainable development also implies social development and equity aspects, which for example can be integrated in the analysis through indicators of poverty alleviation, income distribution and local participation.

Kirsten Halsnæs

Publications 2002: 26, 27, 28, 42, 49

Air Impact Project and Transport

The UNEP Centre is hosting an international website on "Health and Economic Impacts of Air Pollution" in a collaborative effort with a number of international and national institutions. The website aims at improving access to state-of-the-art data on air pollution impacts and enhancing information exchange between experts and policymakers. CD Rom versions of the website were distributed to all delegates at the COP 8.

The Centre is in the initial stages of establishing a subprogramme on transport. The present focus is on transport and fuel policies, sustainable transport indicators, and integrated analytical approaches to analysing environmental aspects of transport policies and projects. The Centre has worked on a study of fuel policies in Latin America with ECLAC and a joint regional workshop was held in Santiago in December to discuss broader regional experiences on fuel policies.

Jorge Rogat

Publication 2002: 8

ENERGY SYSTEMS ANALYSIS

Predicting the development of renewable energy technologies

Renewable energy is considered important to improving environmental performance and the long-term security of energy supply. As most renewable energy technologies are not competitive with the present conventional technologies, there is a need for public support in the liberalised energy market. At the same time, a transition is going on from national, technology-oriented support schemes for renewable energy to more market-based schemes, where all renewable technologies have to compete.

The programme is participating in a project examining the development of as yet uncompetitive renewable energy technologies. This project is being financed by the Danish Energy Research Programme.

The project surveys the historical development of several renewable energy technologies and describes the causal interrelationship between variables such as research support, subsidies, and technological development. In 2002, the focus has been on determining which variables are important for the technological development of renewable energy technologies, and if it is possible to determine an experience curve with these variables that can be used to predict the technological development.

Data analyses

On the basis of time series for wind-power and photovoltaic technologies, a multiple analysis of describing variables including time, accumulated capacity, public research funding, and subsidies were conducted in order to find the most important variables in the dynamic process. Even though it were relatively large time series, caused by multi-colinearity in both data sets, it was not possible to distinguish the effect from the different variables, i.e. an experience curve could be estimated using any of the variables. This analysis also showed the difficulty of quantitative predictions, as the amount of data is often relatively sparse.

Predicting technological development

Most often the experience curve is made on the basis of accumulated capacity. The figure illustrates observations of investment cost for wind-power (diamond points in the figure). In order to see if the experience curve is suited for prediction studies, calculation of four prediction intervals (illustrated at the right side of the figure) were calculated. These were based on the available data in the years 1985, 1988, 1991, and 1994 with respectively 7, 10, 13 and all 16 observation points available. That is, the first interval is calculated as if we were at the end of the year 1985, with the information available from the period 1979-1985, and were trying to predict the costs at a total production capacity at 396 MW. The actual observation at 396 MW is 2.43 kDKK/MWh, and it actually lies outside the prediction interval with 7 observations. In the next interval, it lies at the bottom of the interval. This illustrates the fact that the predictions are higher than the actual observation in all four cases. The error made by using the predicted value is grave in the first two cases of 7 and 10 observations respectively. This means that prediction of price developments within wind power requires at least 10 observations in order to be relatively close to the actual observation.

Generalising the findings

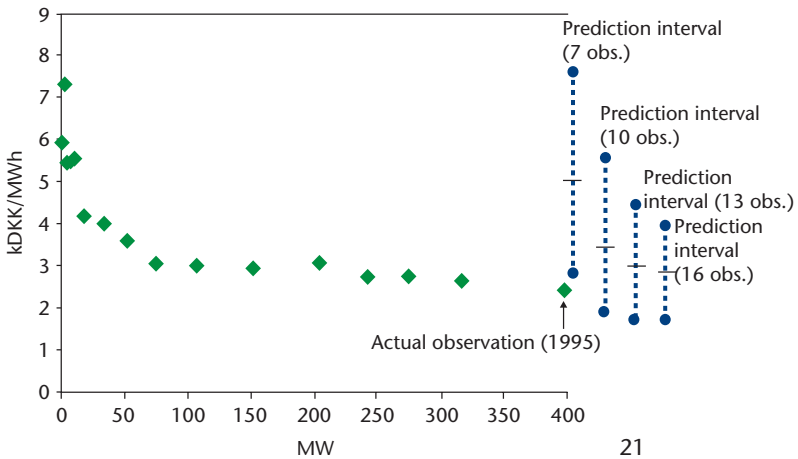
Transferring the above observations to other renewable energy technologies indicates that experience curves are very useful to describe historical observed technology development. However, it is doubtful if they can be used to predict the development, as all renewable energy technologies often have relatively limited data available when prediction is of interest. If the idea of the prediction were to evaluate future investments in renewable energy technologies both by private and public investors, the uncertainty in the investment does not decrease by the use of this type of quantitative method. Thorough understanding of the dynamic aspects of technological developments is therefore necessary in the process of determining support for these immature technologies.

In the year to come more time will be used to structure current findings from historical cases already investigated in order to uncover the dynamic interactions. This will be used to indicate support strategies for immature renewable energy technologies.

Stine Grenaa Jensen & Klaus Skytte

Publications 2002: 48, 54, 73, 123

Prediction intervals of investment cost of wind power with the capacity 396 MW based on a different amount of observations.



The power market and investments in new capacity

For the last two years Denmark has successful participated in the Nordic power market, NordPool, a large proportion of Danish power production being supplied to that market. Nevertheless, some doubt exists as to whether the power market is capable of generating the investment necessary for new power capacity in the years to come. Existing market experience is related to a time period with excess capacity of power and therefore is on the basis of the day-to-day operations of the power system. Until now no major investment in new power capacity has been undertaken under market conditions. Thus it is an open question whether the Nordic power market is capable of sending the right price signals to new investors in order to establish the new production capacity needed to meet the demand for power in the future.

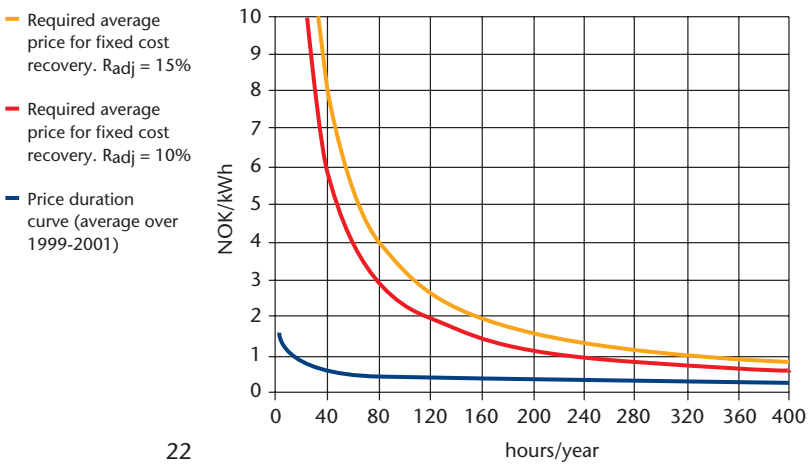
Recently Risø was involved in a project initiated by the two Danish TSOs (Transmission System Operators) and the Danish Energy Authority addressing policy instruments to ensure the development of power capacity in the Nordic power market. The project was completed mid 2002. To get an idea of the importance of this field of research, some of the major findings from this project follow here. Previously, regulated electricity sector investment planning was based on cost minimization and demand was assumed inelastic. In a liberalised market, investment decisions are made on the basis of market prices and in order to motivate new investment these market prices must from time to time exceed the variable cost of the most expensive unit if all available capacity is sold in the market and price is determined by the consumer's willingness to pay.

In a hydro-based system with some degree of storage possibilities, such as in the Nordic area, prices are to a large extent determined by the value of water stored in reservoirs. Under dry conditions, as seen during last winter (2002/2003), the potential loss of revenue from running a reservoir dry (an opportunity cost) can lead to relatively long periods of high prices with the potential to motivate new investment. As water values are a function of the expected loss of revenue during energy shortage, expected consumer flexibility or price elasticity of demand reflected through the market price will indirectly determine the price and thus the incentive for new investments. A price-responsive demand curve that reflects the true preferences of consumers is therefore an essential precondition for economically efficient investments in new production capacity, both in capacity (thermal, wind, biomass etc.) and hydro/energy-based electricity markets.

With regard to security of supply, the crucial role of the responsiveness of demand to price is a significant change compared to a regulated system, where consumers were charged a fixed tariff and capacity was dimensioned to handle demand under all conditions.

The Figure illustrates the large gap which exists today between system market prices on the NordPool spot market and the prices required in order to motivate new investments in peak load capacity. The figure assumes a gas turbine as a peak load unit with a fixed cost of 2,000 NOK/kW and an expected lifetime of 20 years. Using a range of risk-adjusted discount rates of 10-15% the required annual cash flow becomes 235-320 NOK/kW. By dividing this figure with the number of hours that the plant will operate each year (i.e. capacity factor times 8,760 hours/year), and adding variable costs the red curves in the figure can be derived illustrating the average kWh price required to recover the investment. The blue curve is a price duration curve for the system spot price averaged over the three years 1999-2001. For each point on the blue curve, the y-value represents an average of the highest prices each year. The figure clearly illustrates that prices are well below the level required to motivate investments in peak load capacity, even when taking into account that on average the period 1999-2001 was dominated by a high precipitation for hydro plants, and that peak capacity was normally able to collect some revenue in the regulating power market. Fluctuations in demand within annual periods are weather driven and some level of peak load capacity running at a low capacity factor is required. Price peaks must therefore increase significantly beyond the current levels. Thus politicians

Average spot prices required to recover the investment compared with the realised price duration curve for the period 1999-2001.



and consumers must be prepared for periodically high prices, as these are an inherent part of electricity markets. The large variations in system energy due to the large amount of hydro-power and the high dependence on temperature increase the risk for investments in peak load capacity. Financial contracts between supply and demand must be developed to spread this risk. It is important to note that this risk was also present in the regulated system, where consumers collectively paid for the risk through the excess capacity.

To continue the work within this important field a new project was started by Risø in autumn 2002 in collaboration with the Danish TSOs, Eltra and Elkraft System. This project is being funded by the Danish Energy Research Programme and is expected to be completed in 2004. The major objectives of the project are threefold:

1) To simulate how prices are determined at the Nordic power market in order to show the importance of price-elasticity of electricity consumers and investor behaviour.

2) To evaluate, and if possible quantify, the possibilities for expanding the Nordic power market, e.g. with a separate market for developing new capacity, or a tendering procedure for investments in new power plants.

3) To analyse the relevant criteria governing investor decisions for building new power capacity, among these the required return on investments, characteristics of potential new power producing facilities, and the specific requirements for spin reserves.

The most important of these issues is to address the simulation of future price patterns in the existing power market. Price simulations will mainly be carried out by the use of existing modelling tools, while new minor partial models will be developed for analytical purposes to obtain an improved understanding of the mechanisms that underlie investor behaviour.

Jacob Lemming and Poul Erik Morthorst

Socio-economic analysis of centralised biogas plants

The development of biogas technology in Denmark has been widely encouraged by the government over the last 15 years. The overall reason for government concern is the increasing awareness that centralised biogas plants contribute to solving a range of problems in the fields of energy, agriculture and environment. To achieve an evaluation of new centralised biogas plants equipped with best-known technology, Risø National Laboratory and the Danish Research Institute of Food Economics, c/o University of Southern Denmark, have carried out a thorough socio-economic analysis for the Danish Energy Authority.

Externalities

Conventional economic analyses and corporate investment analyses of projects do not take into account externalities. Externalities or external effects neither imply expense nor income elements for the corporate or private investor. However, externalities are important economic effects from the point of view of society.

Biogas projects not only have implications in the agricultural sector, but in the industrial and energy sectors as well, and among the environmental consequences, mitigation of pollution, greenhouse gas (GHG) emission reduction and reduced eutrophication of ground water etc. are important external effects.

Approach and monetised externalities

This socio-economic analysis has been carried out at different levels, where the levels in succession take into account still further the external effects related to the biogas scheme. Four levels have been chosen for the analysis. Termed Result 0, 1, 2, or 3, these differ according to the externalities included in the analysis.

As seen from the Table "Result 0" does not include external effects in the socio-economic analysis, and benefits concern the energy production from the plant only. Analyses at the higher levels, however, take externalities into account and further cost and benefit elements enter the analysis. The socio-economic levels of analysis are characterised by:

- Result 0: Energy production (biogas and electricity) from biogas plants. Externalities are not included.
- Result 1: Benefits in agriculture and industry are added to the analysis.
- Result 2: Environmental externalities concerning GHG emissions (CO_2, CH_4, N_2O) and N-eutrophication of ground water are also included.
- Result 3: A monetised value of reduced obnoxious smells from digested biomass is also included in the socio-economic analysis.

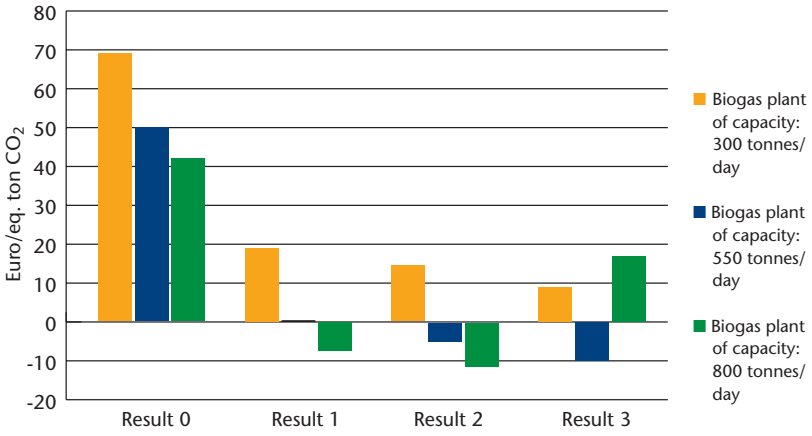
Considerable effort has been put into the assessment of biogas scheme externalities. However, due to lack of data important further external effects have not been quantified and monetised for the analysis. Among such aspects are: increased flexibility at farms associated to biogas plants; effect for the security of energy supplies;

Annual costs and benefits. Results based on biogas plant outlined for treatment of 550 tonnes per day

Socio-economic results. Biogas plant size: 550 tonnes/day (20% waste)

	Result 0	Result 1	Result 2	Result 3
Costs (levellised annuity)		mill.EUR/year		
Investments, operation and maintenance:	1.481	1.481	1.481	1.481
Benefits (levellised annuity)				
Energy production:				
Biogas sales	0.526	0.526	0.526	0.526
Electricity sales	0.061	0.061	0.061	0.061
Agriculture:				
Storage, handling and distribution of liquid manure		0.032	0.032	0.032
Value of improved manurial value (NPK)		0.186	0.186	0.186
Value of reduced obnoxious smells				0.097
Industry:				
Savings related to organic waste treatment		0.675	0.675	0.675
Environment:				
Value of GHG reduction (CO_2, CH¤, N_2O-reduction)			0.605	0.605
Value of reduced N-eutrophication of ground water			0.079	0.079
Sum:	**0.588**	**1.481**	**2.165**	**2.262**
Surplus as annuity: Benefits - costs	**- 0.893**	**0.000**	**0.684**	**0.781**

Annual costs and benefits. Results based on biogas plant outlined for treatment of 550 tonnes per day.



Equivalent CO_2 reduction costs achievable via biogas schemes

veterinary aspects; employment effects and effects on trades and industries. The Table shows the annual costs and benefits at the four levels of the socio-economic analysis. A socio-economic rate of calculation of 6% p.a. has been used, and the analysis covers the period 2001-2020. Values shown are at year 2000 price levels.

It is seen from the Table that the biogas scheme is not attractive under Result 0, where it has been assumed that benefits only concern energy production from the plant. Result 0 shows a socio-economic deficit of about EUR 0.89mill./ year. However, taking into account agricultural benefits and industry cost savings in waste disposal, Result 1 shows socio-economic break-even.

If the environmental benefits described (GHG emission reduction and reduced N-eutrophication of ground water) are also included, result 2 shows a surplus of about EUR0.68mill./year. And including the value assumed for reduced obnoxious smells from liquid manure on fields relative to the reference the socio-economic surplus adds up to about EUR 0.78mill./year. Thus, from an extended socio-economic point of view, under Result 3 assumptions, the biogas scheme is highly attractive.

GHG emission reduction costs

The relevant Green House Gasses (GHGs) affected by biogas plants are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The detailed analyses show that CO_2, CH_4 and N_2O contribute about 44%, 48% and 8% respectively to the total GHG reduction achieved for centralised biogas plants. In the Table above GHG emission reduction has been assigned the external value of EUR 33.6 /tonne CO_2 equivalent reduced (or DKK 250 /tonne CO_2 equivalent). The Danish Energy Authority has used this value in a recent study.

In the Figure the equivalent CO_2 reduction costs are presented for three biogas schemes. Results of the socio-economic analysis expressed by this key number allow decision-makers to interpret results on the basis of diverse CO_2 reduction cost aims. To illustrate economies of scale regarding the size of plants, the figure presents equivalent CO_2 reduction costs achievable via biogas plants with treatment capacities of 300, 550 and 800 tonnes biomass per day.

From the Figure it is seen that GHG reduction costs based on Result 0 assumptions are in the order of magnitude of EUR 50 /tonne CO_2 equivalent. The economies of scale show gains for larger plants, indicating that the increased transport costs and transport fuel consumption for the larger plants are counterbalanced by the overall benefits. Results 1, 2 and 3 show socio-economic GHG reduction costs below zero. Thus, larger biogas projects may contribute important GHG reduction, while concurrently generating considerable socio-economic gains.

Lars Henrik Nielsen

Publications in 2002: 97, 150, 131

Policy implications of Tradable Green Certificates

Which energy policy instruments would be the most appropriate to meet the Kyoto requirements on CO_2 emission reduction has been widely discussed. Obviously, an emission quota system will be a feasible instrument by addressing the emission problem directly. In addition, since emission is a global and not a local problem, allowing for international reduction trading arrangements will likely enhance the effectiveness of a quota system. Knowing that emissions reduction can be achieved in only two ways, either by fuel substitution or by reduction of energy consumption, fuel substitution seems to be the most rewarding approach. Substitution with renewable energy sources will also address the emission problem directly, so promotion schemes for renewable energy sources, such as tradable green certificates, have been proposed as an energy policy instrument intended to be implemented jointly with emission quota systems.

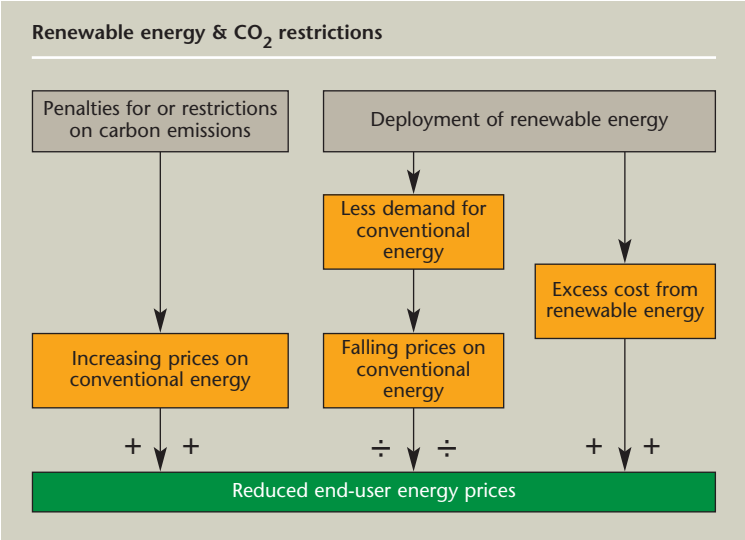
In 2000 a group of researchers from Risø, University of Southern Denmark, the Association of Danish Energy Producers, and the two Danish TSOs (Transmission System Operators), Eltra and Elkraft System, initiated a research project. The aim was to investigate the interaction between an international green certificates market and other energy policies. The project was concluded in 2002, and many of the results have been published in a special issue of Energy Policy, January 2003.

The clear main result of the analysis is due to the fact that an emission policy will impose an extra cost on all conventional electricity, which constitutes the main part of the electricity supply, whereas a green certificate system only imposes an extra cost on green electricity. Furthermore, the deployment of green electricity will supersede the supply of conventional electricity, hence reducing the spot prices of electricity.

Peter Fristrup

Main result

The deployment of electricity supply from renewable energy sources (RES-E) is likely to be achieved without extra consumer cost through proper use of both Tradable Green Certificates (TGCs) and Tradable Emission Permits (TEPs). Using these policy instruments concertedly, the cost of deployment will be financed through profit absorption among conventional power plants.



The diagram shows how a carefully managed deployment of renewable energy counterbalances the cost of meeting the Kyoto targets on carbon emissions.

Key observations

- A price subsidy to RES-E might not be fully transferred to the RES-E supplies. The subsidy will be partly eroded if the supply of conventional electricity is competitive. This is due to the falling marginal cost of the conventional supply, caused by the reduced share of conventional supply.
- Emission taxes and TEP systems induce the same ranking of power plants implying the same emissions from producing a given quantity of electricity. Since the TEP system by definition is "right-on-target", it will be superior to emission taxes in quantity management.
- A stand-alone TGC system makes it hard for RES-E suppliers to appropriate the value of the corresponding emission gains. A TEP system will facilitate this appropriation. Furthermore, a TEP system will also make it easier to meet both short and long term RES-E deployment goals with a TGC system.
- Applying both TGCs and TEPs is likely to induce synergy effects. Both theoretical and empirical studies support the existence of a "negative correlation scenario" where the additional cost of using the TEP scheme exceeds the additional cost of using the TGC scheme.
- An EU wide TGC system would be preferable, since it would allow for more TGC market participants, and a coincidence with the TEP market. Hence, compatibility and future harmonisation should be strongly considered when designing national systems.
- Fixed feed-in tariffs to RES-E exposes wind turbine owners to large variations due to climate variations. Wind turbine owners are likely to gain from a system with compulsory demand for TGCs combined with a forward market on TGCs.

Summary Statistics

By the end of the year the total number of employees in the department was 70, of whom 22 were women and 48 men. More than 90 per cent of the staff has an academic background. The age distribution shows that 30% of the staff is 30-39 of age, 26% is between 40-49 and 26% is in the range 50-59 years.

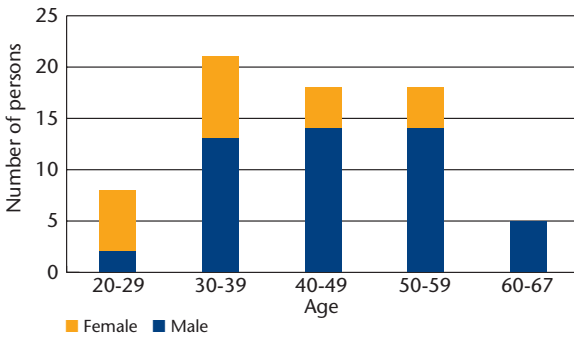
The number of publications in 2002 totalled 152, of which 42% were international publications and 24% Danish publications. The conference contributions make up 27% of the publications and popular publications make up 7%.

In 2002, 69 per cent of the department's activities were financed through national and international research contracts, contracts with national agencies and international organisations, as well as contracts with industrial companies – especially in the energy sector. The remaining 31 per cent of activities were financed by governmental appropriations.

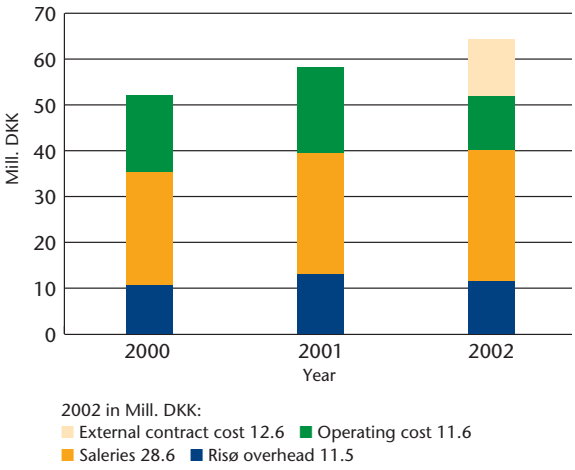
The total gross / net turnover of the Department for 2002 amounted to approximately DKK 65.7 mill./DKK 53.1 mill. (EUR 8.84 mill./ EUR 7.13 mill.)

Staff 2002	Females	Males	Total
Academics:			
Head of department and programmes	0	5	5
Research specialists	1	1	2
Senior scientists/consultants	6	26	32
Scientists	2	7	9
Research assistants	1	0	1
Technical/administrative staff	2	2	4
PhD students	6	6	12
Technicians	0	1	1
Secretaries	4	0	4
Total staff	22	48	70

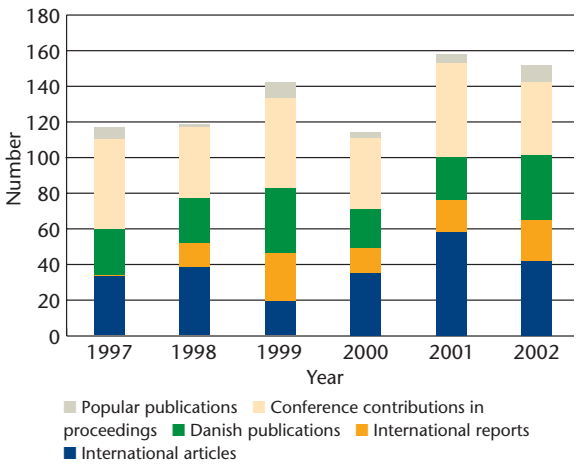
Age and gender distribution 2002



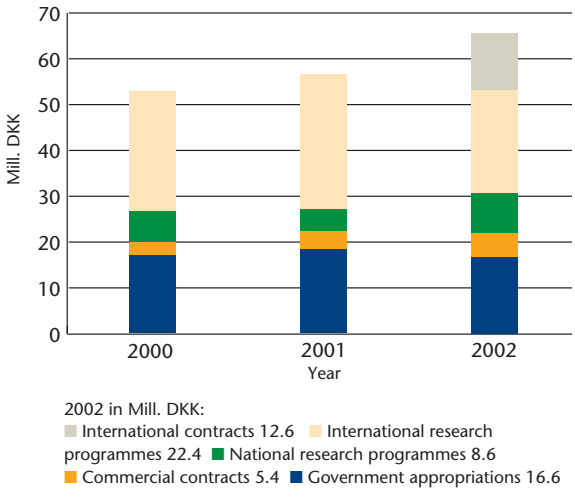
Expenditures 2000-2002



Publications



Revenues 2000-2002



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